X-band Structure Design For The NLC

Zenghai Li

Design Considerations

- Emittance preservation, tolerance specs – wakefield suppression
  - Short-range wakefields $\propto a^{-3.8}$: set lower limit on aperture: $a \cong 0.18\lambda$
  - Long-range wakefields: mode detuning and damping
- Minimizing surface field
- Reducing breakdown damage
- Minimizing RF pulse heating
- Cost effective
- …

Continuing Improvements

- Breakdown problems with 1.8m structure (RDDS, DDS)
  - Low achievable gradient
  - Severe damage, large frequency shift
- C.Adolphsen theory
  - .
    $$\frac{G^2 v_g^2}{(R/Q)^2} \frac{\sin(\phi)}{\phi \sin(\phi) + 2 v_g \cos(\phi)}$$
  - Low v_g or low RF power/structure
- Structure design approach
  - Traveling: $v_g/c \sim 3\text{-}5\%$
  - Standing wave: $v_g=0$

Low v_g With Large Aperture

- Traveling wave
  - Magnetic coupling (rf heating?)
  - High phase advance (bandwidth?)
- Standing wave (short length)

Traveling Wave Approach

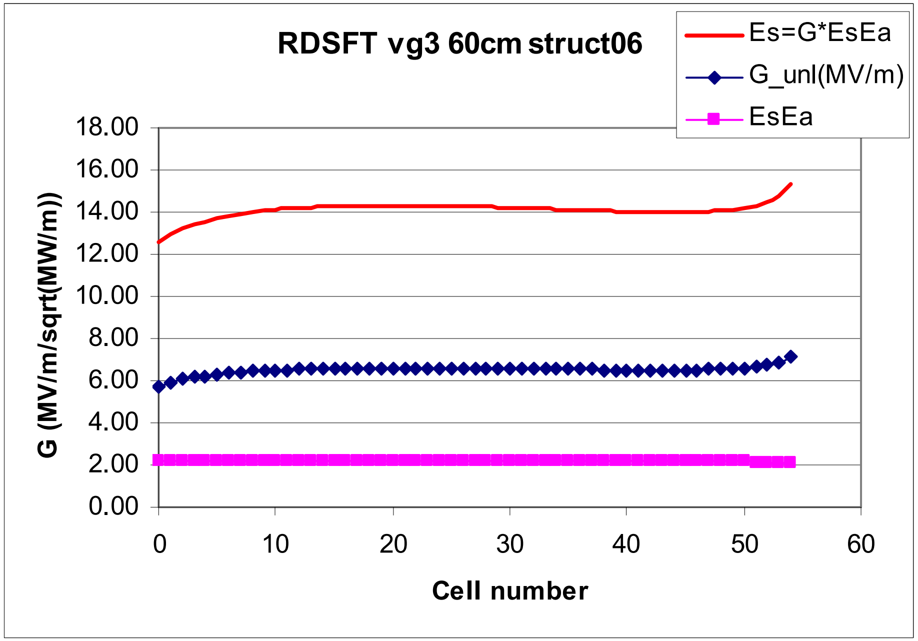
High Phase Advance – 150^0/cell

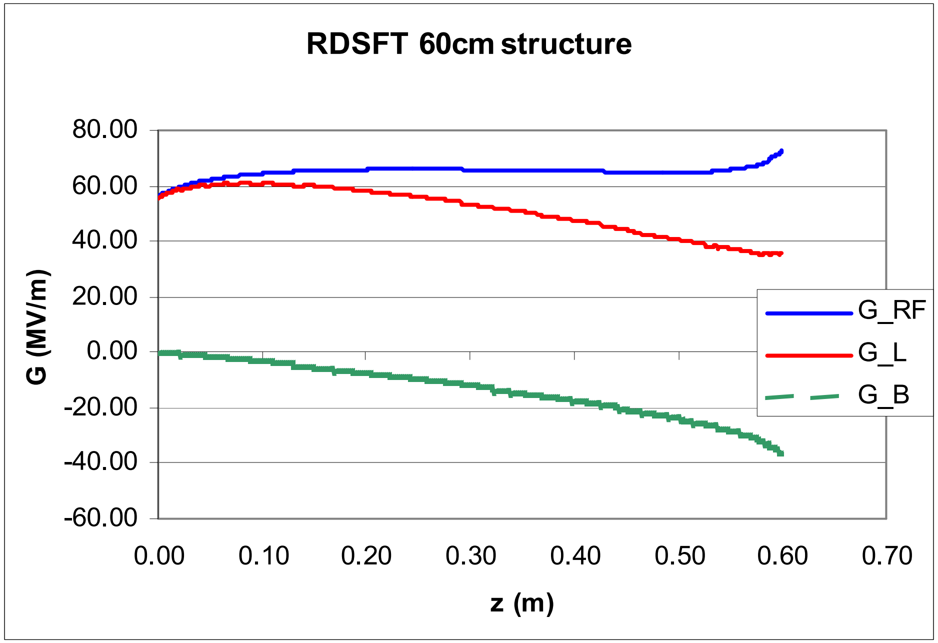
- With Phi=150 deg, one can
  - reduce v_g
  - maintain large aperture
  - maintain good rf efficiency

- Shorter length due to low v_g
- Low input power per structure
- Low surface field

H60VG3 Structure

T_{fill} (ns)	110
τ	0.54
P_{RF} (MW)	58.85
I (A)	0.9
G_{RF} (MV/m)	65.0
G_B	-13.8
G_L	51.0





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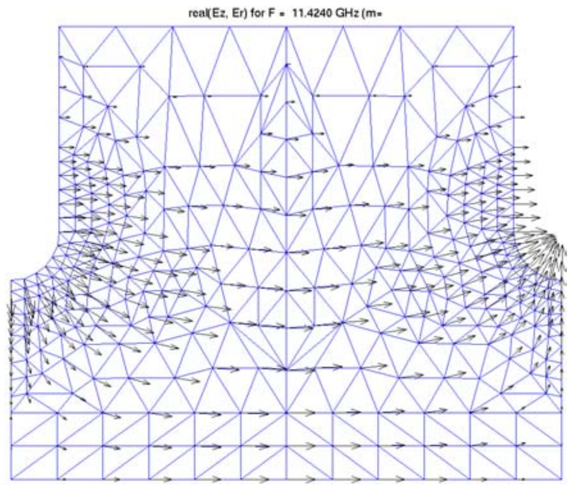
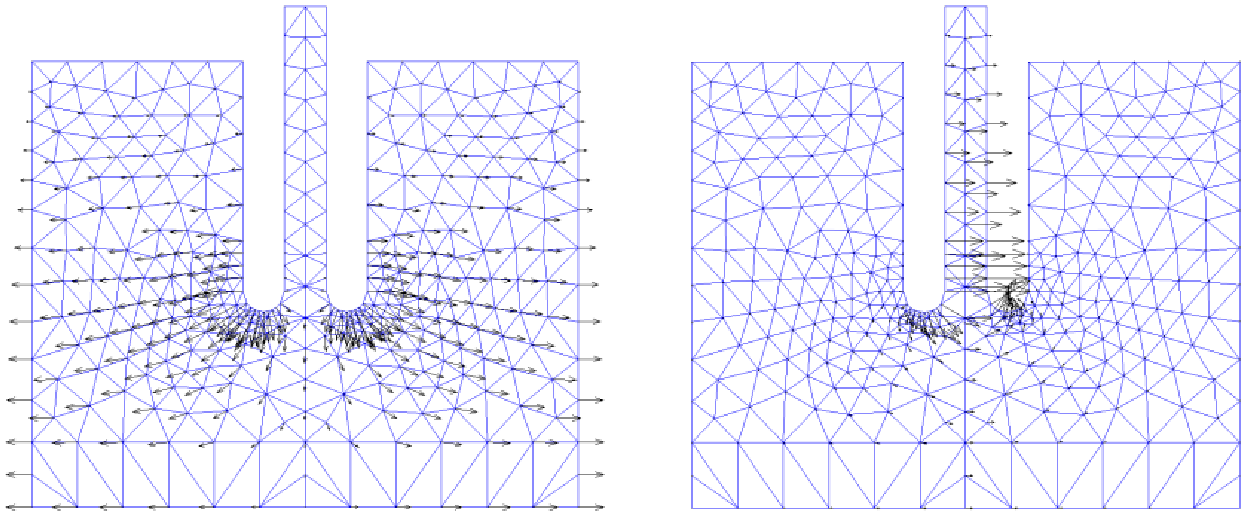
Standing Wave Approach
PI-mode *vs* PI/2 Bi-periodic

PI-mode



PI/2-mode



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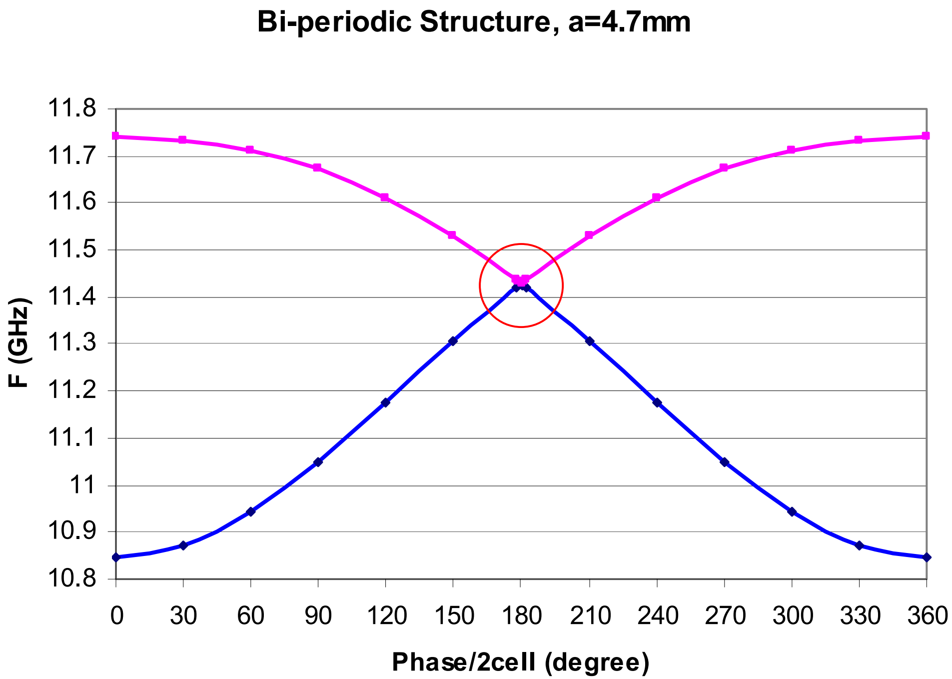
Bi-periodic Structure m=0 Mode



A = 4.7mm
F = 11.424 GHz
Q = 8463
R = 70.2 MΩ/m
R/Q = 8291
Es/Ea = 3.314

- Large mode separation, can be longer in length
- Major concern - multi-pactoring in coupling cell
- Twice as many cells
- Efficient (with thin disk,but maybe high in Es/Ea)

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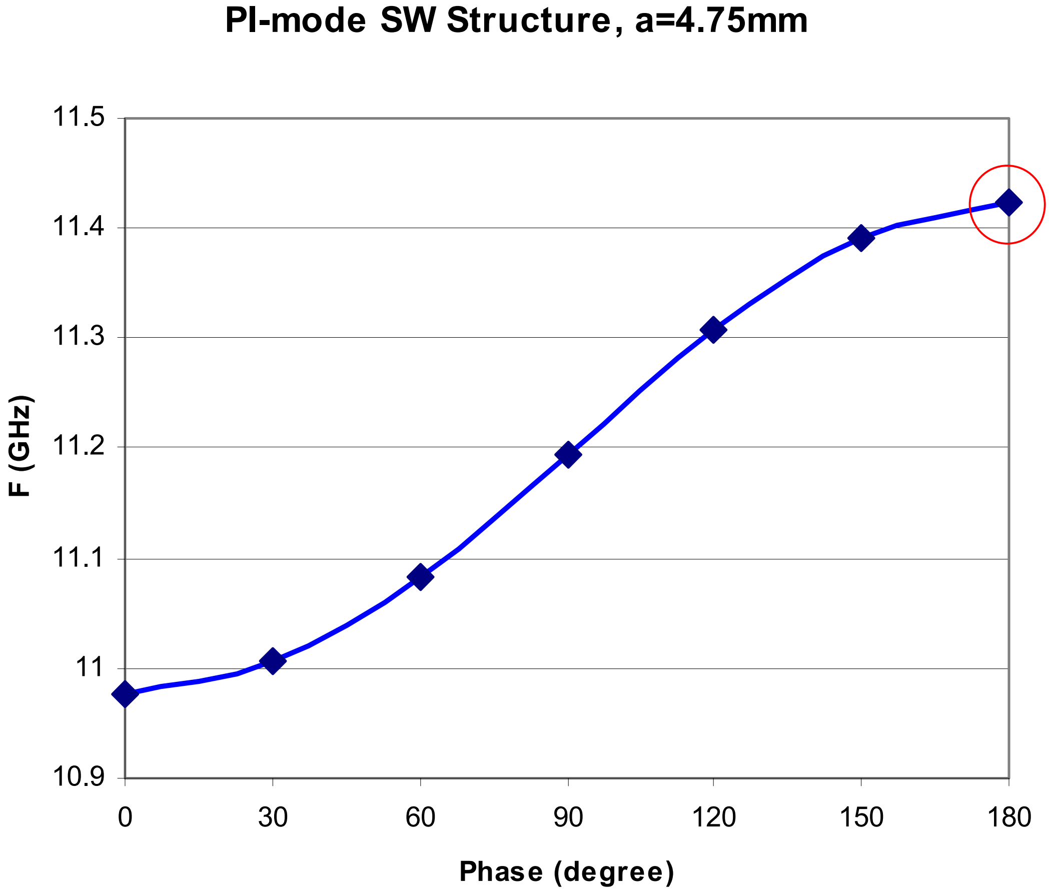
PI-mode SW Structure

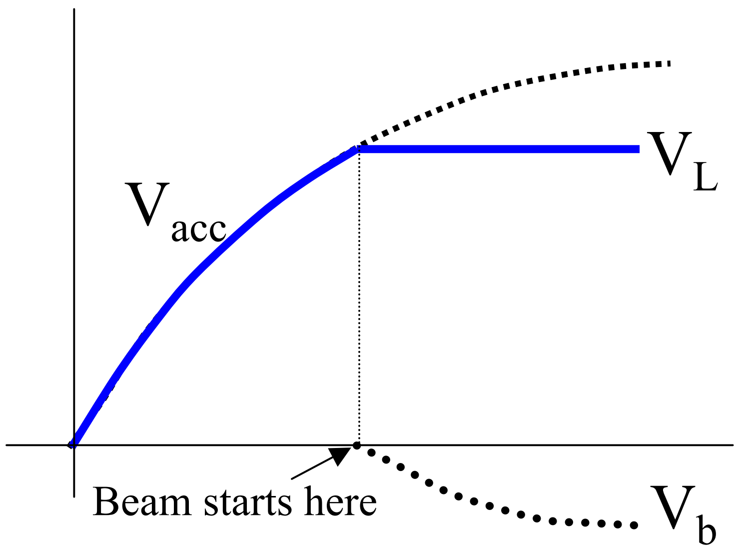


A = 4.75 mm
F = 11.424 GHz
Q = 8820
R = 68.0 MΩ/m
R/Q = 7710
Es/Ea = 2.646

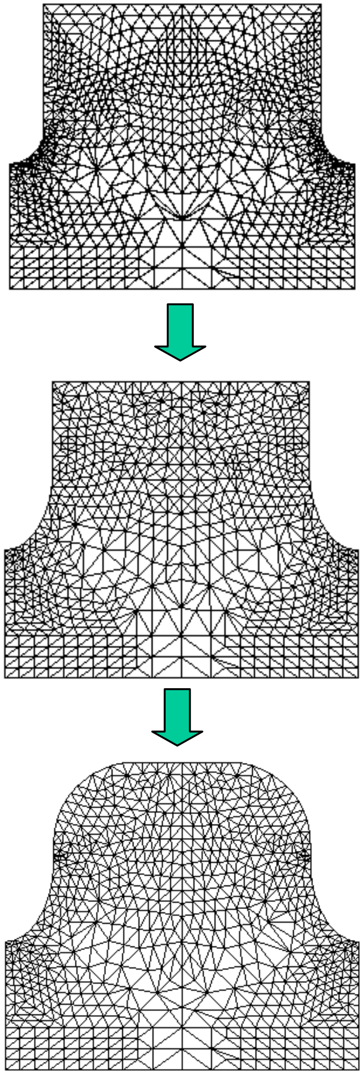
- Dense modes at PI
- Short structure length
- Low surface field with thick disk

Standing Wave Design

- PI-mode
- Short length
- Low input power and stored energy in structure
- Structure always operate at loaded gradient (55MV/m *vs* 70MV/m unloaded)
  - Coupling design for nominal current.
  - Adjust rf power at beam injection for different current



Cell Profile



	DLWG Thin T	Ellip iris Thick T	Round
A (mm)	4.75	4.75	4.75
T (mm)	2.6	3.6	3.6
R (MΩ/m)	67.7	64.2	71.7
R/Q	7742	7519	7478
Es/Ea	2.53	2.08	2.09

- PI mode
- Rounded cell
- Detuned
- Average *a*: 0.18λ
- Es/Ea designed to be about 2

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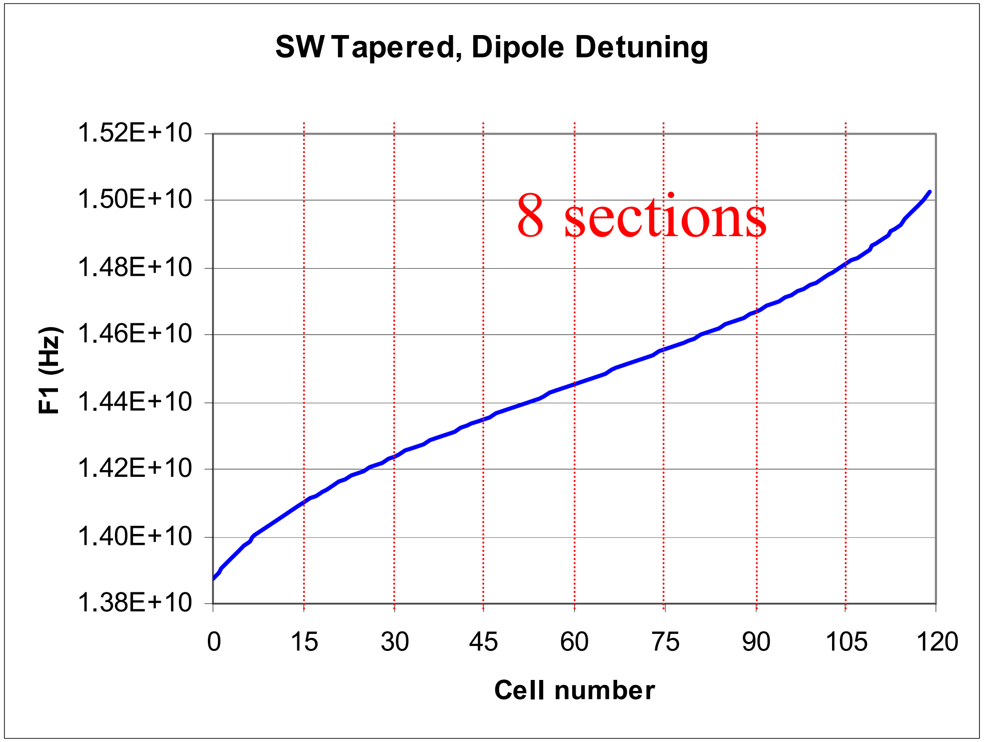
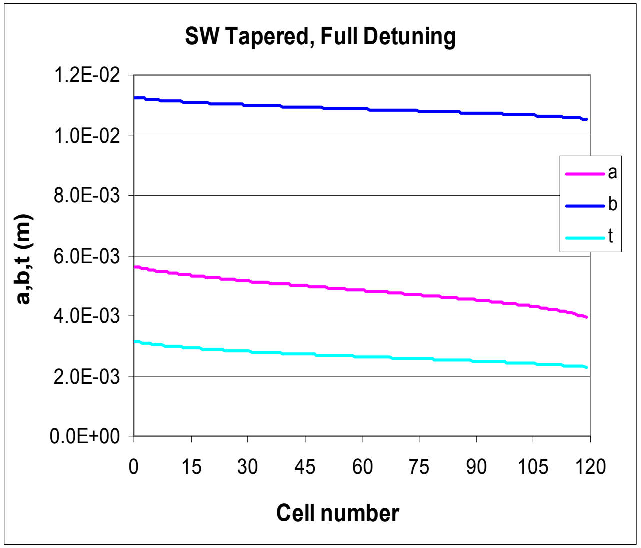
Dipole Mode Detuning

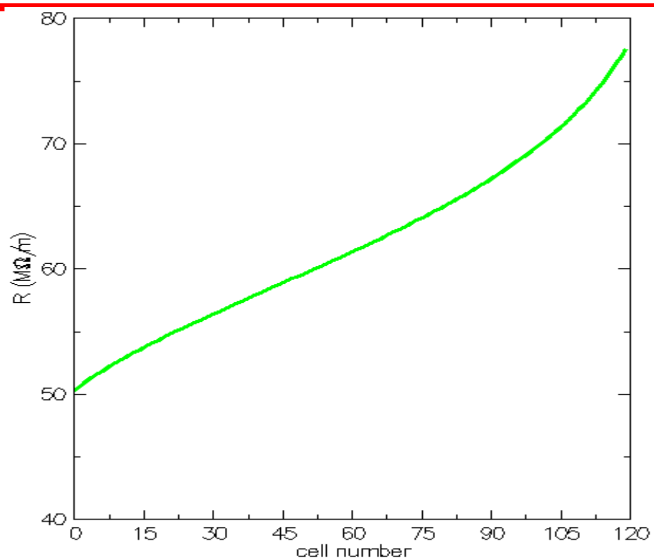


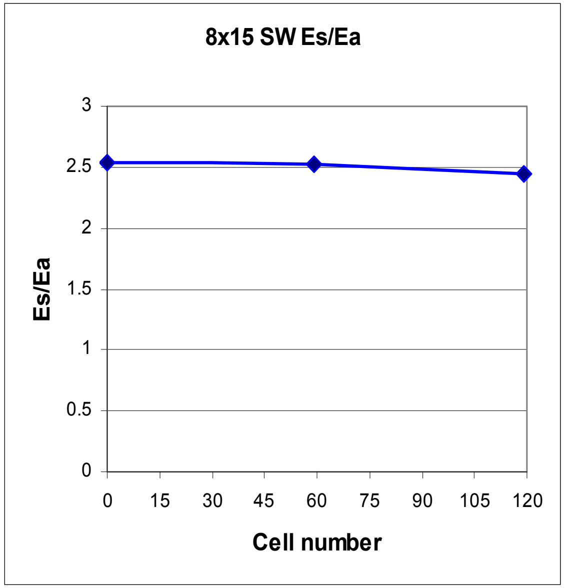
- Need similar detuning as TW ΔF_1=8~10%/4σ
- Cannot detune within one structure
- Detune in 8 sections, 15 cells each (20cm)(not interleaved)
- 120 cells to detune full 8-10% spectrum

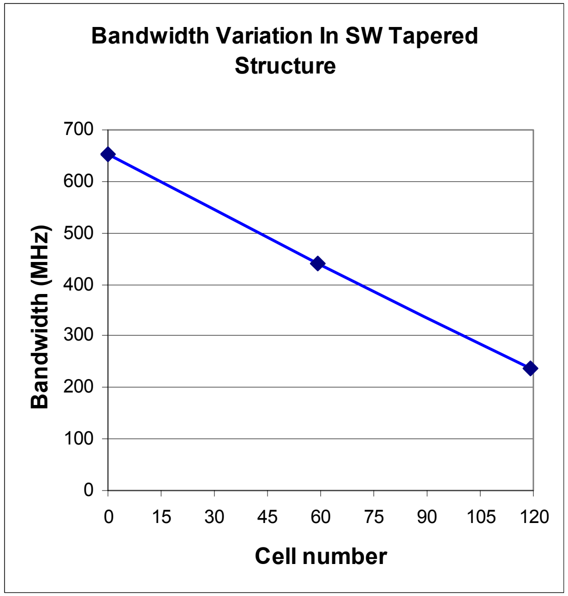
Tapered Structure Parameters (round iris)

- Inverse taper in "t" for wider bandwidth at small "a"
- Adjust cell parameters to obtain flat field





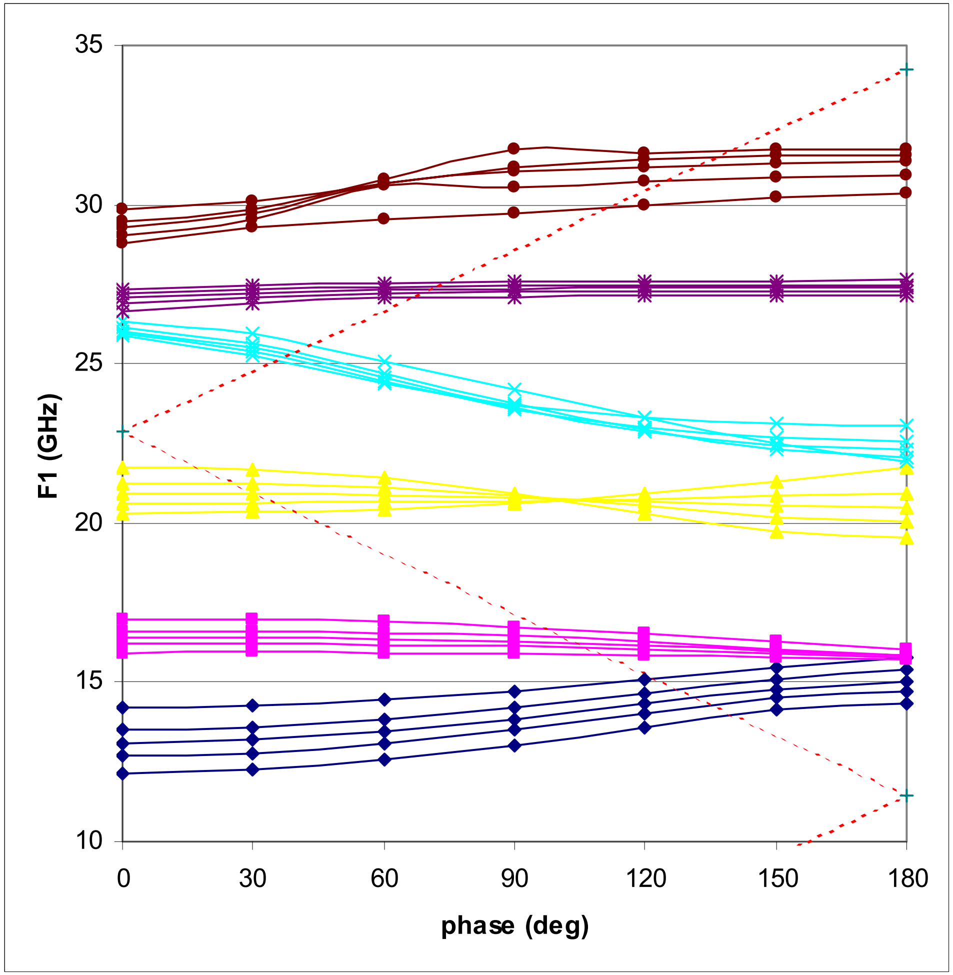




RF Parameters Of 8X15 Sections

	S1	S2	S3	S4	S5	S6	S7	S8
R(MΩ/m)	52.1	55.0	57.6	60.0	62.6	65.5	69.0	74.0
P(MW) for G=70MV/m	18.5	17.5	16.7	16.1	15.4	14.7	14.0	13.0
G(MV/m) for P=22MW	71.1	73.1	75.8	76.3	78.0	79.8	81.9	84.8

8X15 Detuned Dipole Dispersion



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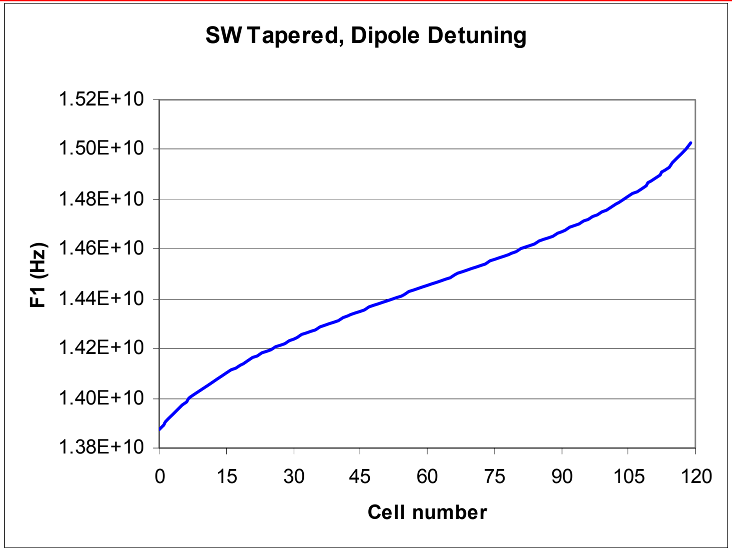
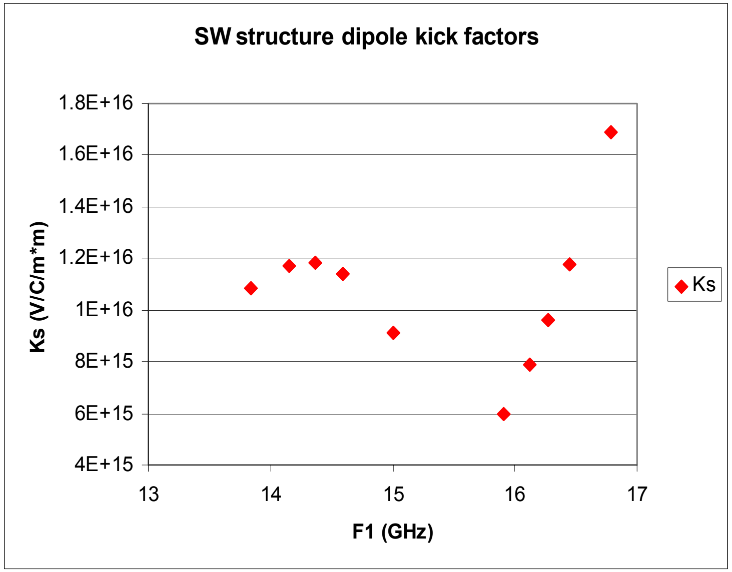
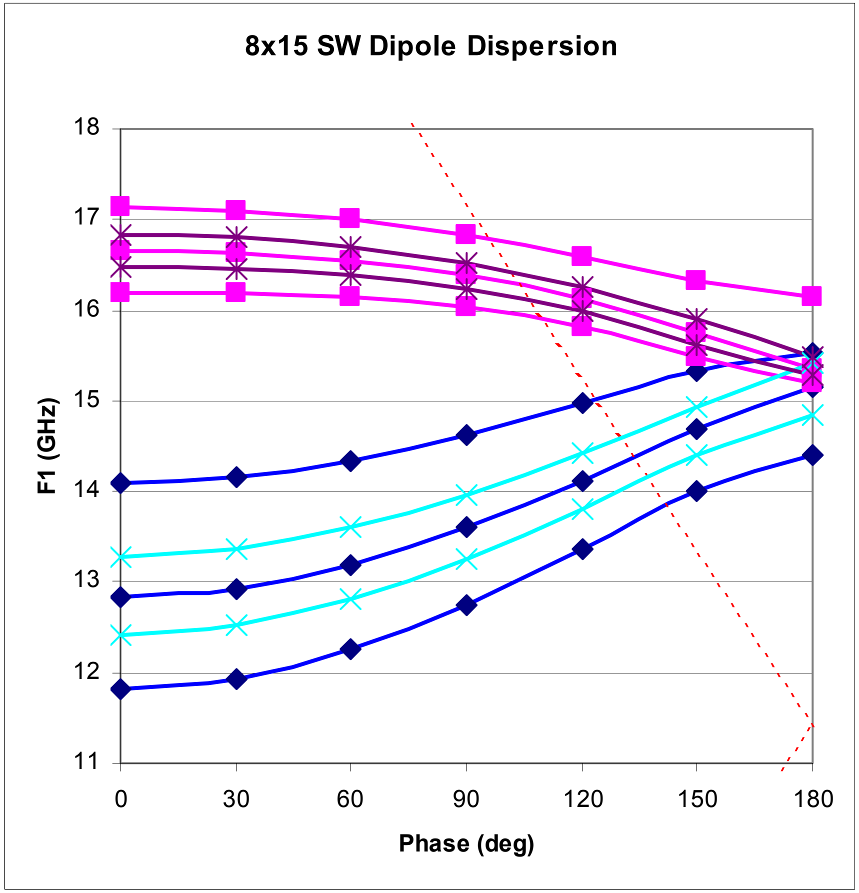
Dipole Mode Kick Factor





ΔF=8%/3.2σ



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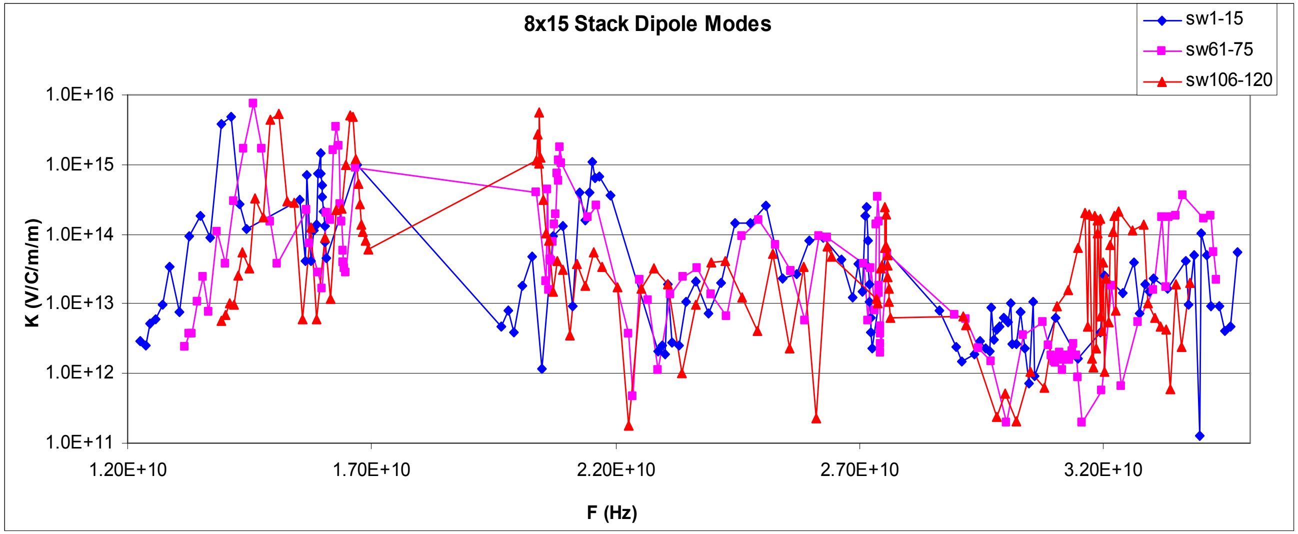
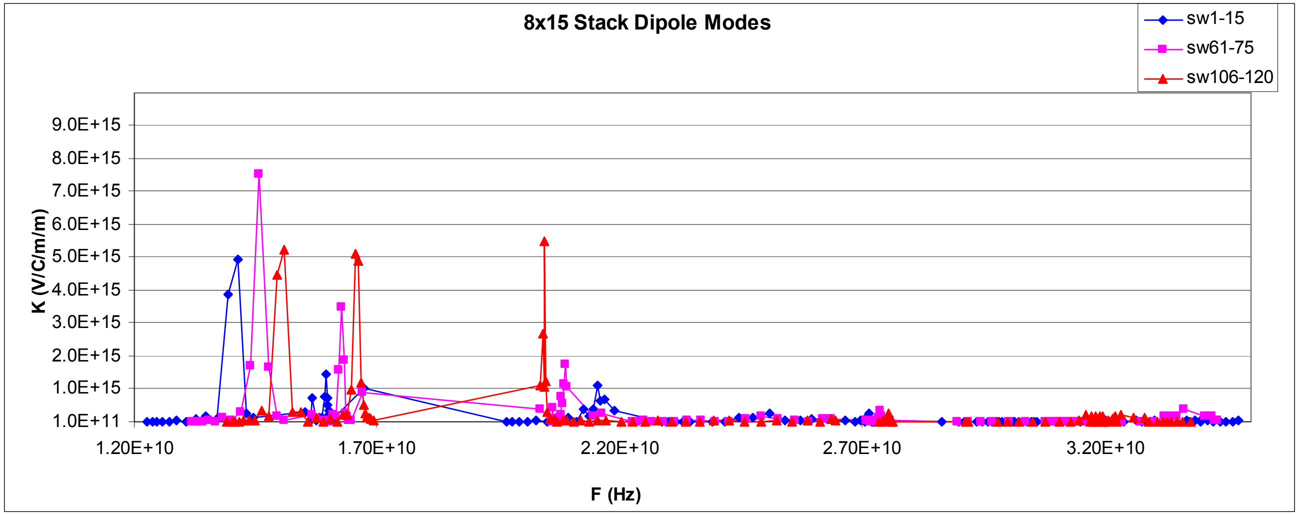
8x15 Stack Dipole Kick Factors



Log



Linear

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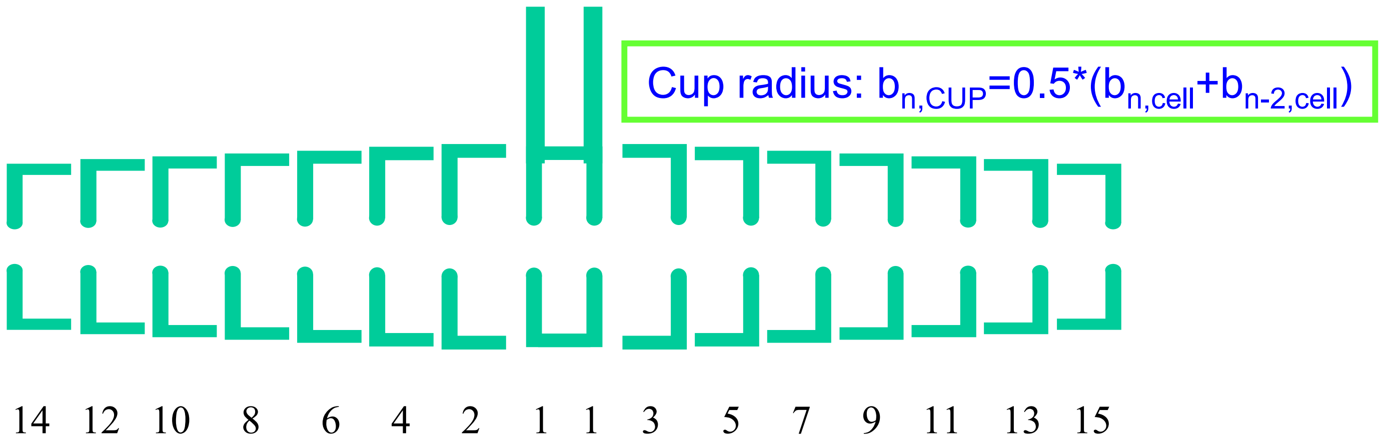
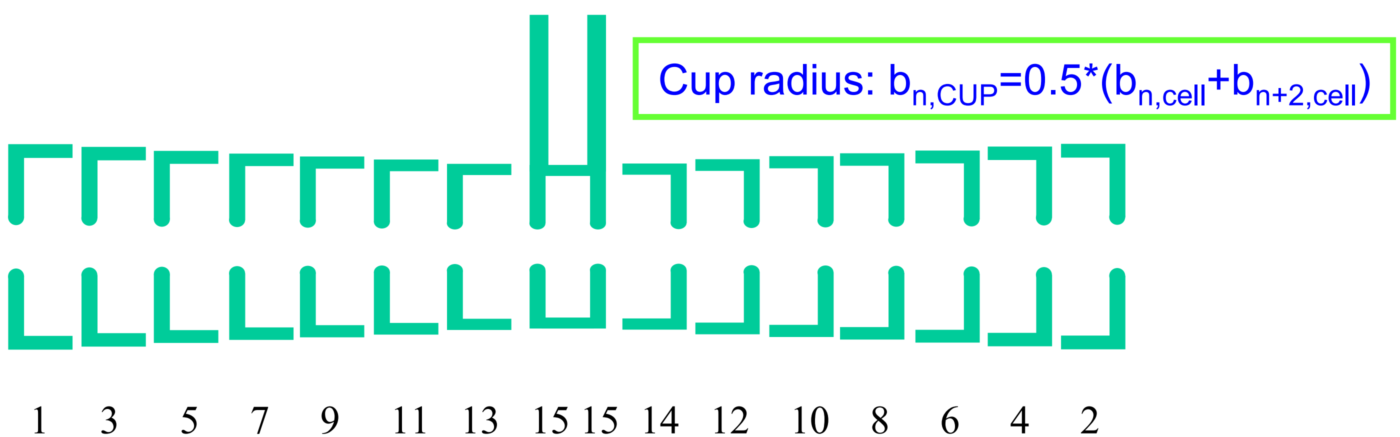
Detuned Standing Wave Structure (?)
Field Symmetric

(A)



(B)



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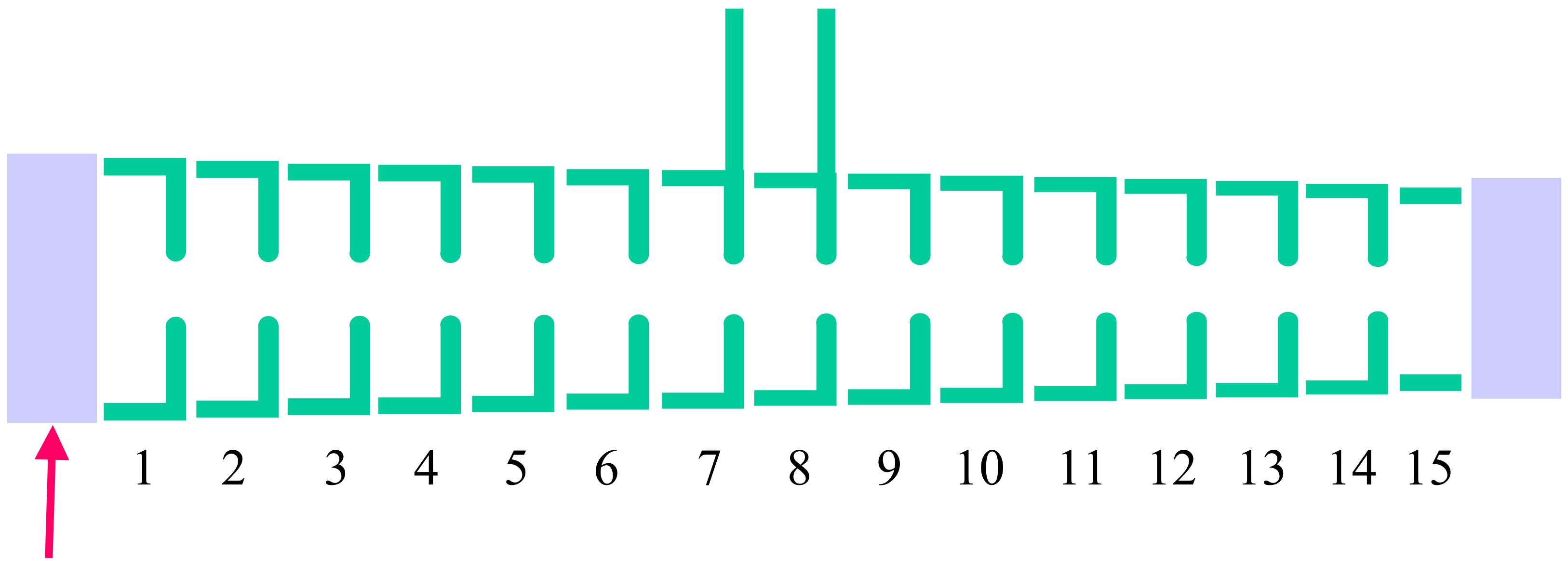
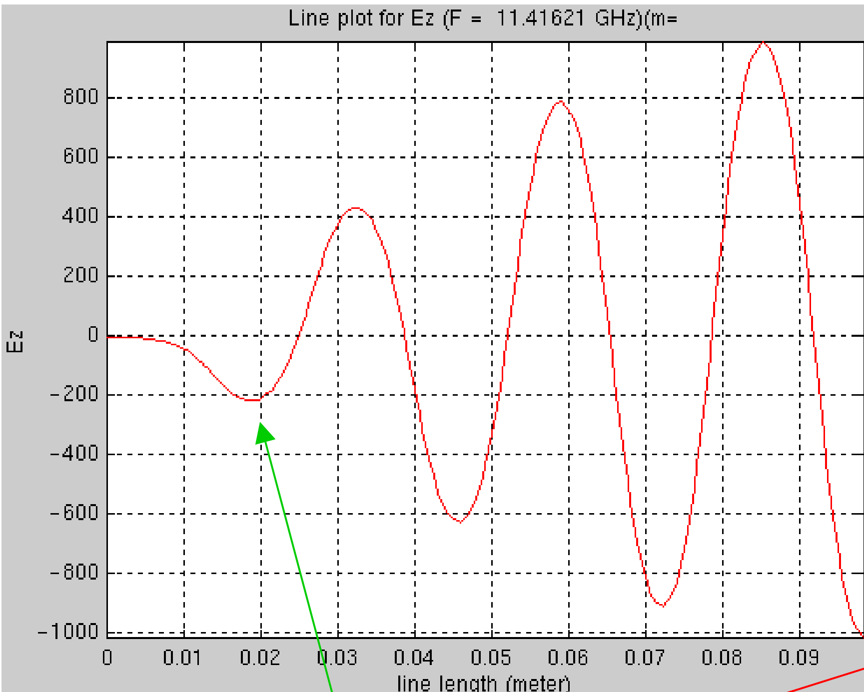
Detuned Standing Wave Structure Assembly

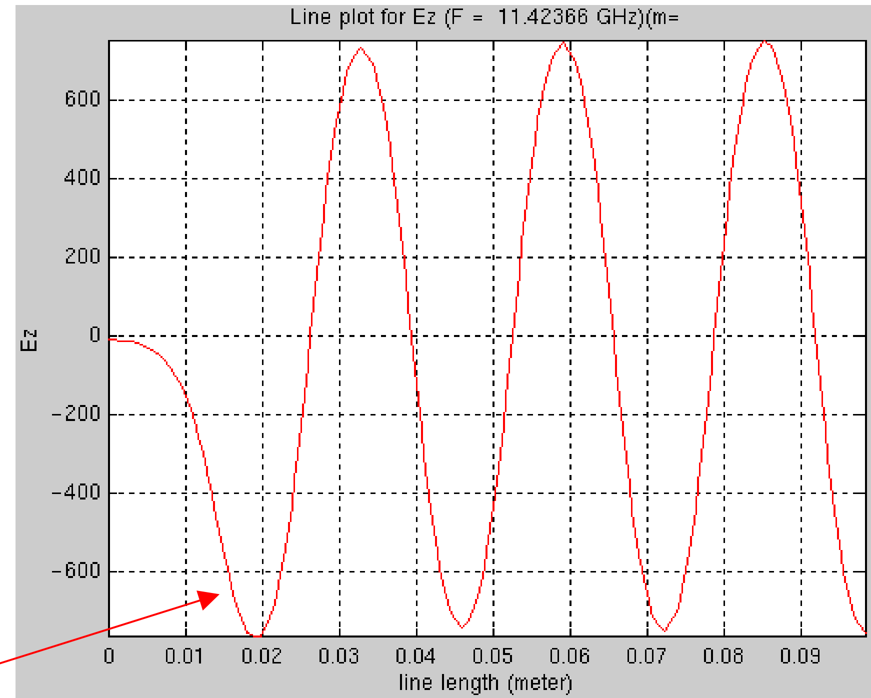


end piece: $a = a_{cell30}$, $t = t_{cell30}$

Cup radius: $b_{n,CUP} = 0.5*(b_{n,cell} + b_{n-1,cell})$

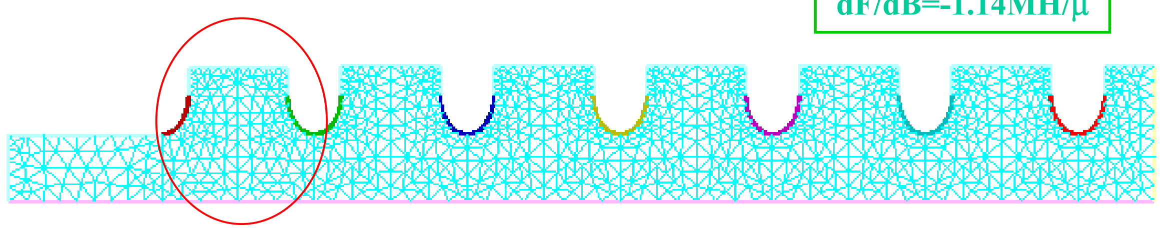
Flattening Field By Adjusting End-“b”





A	0.00565	0.00565
B (cell 1)	0.0115194	0.0113774
B (cell regular)	0.0115194	0.0115194
T	0.0046	0.0046
A_{nose}	0.0034	0.0034

(single cell)
dF/dB=-1.14MH/μ



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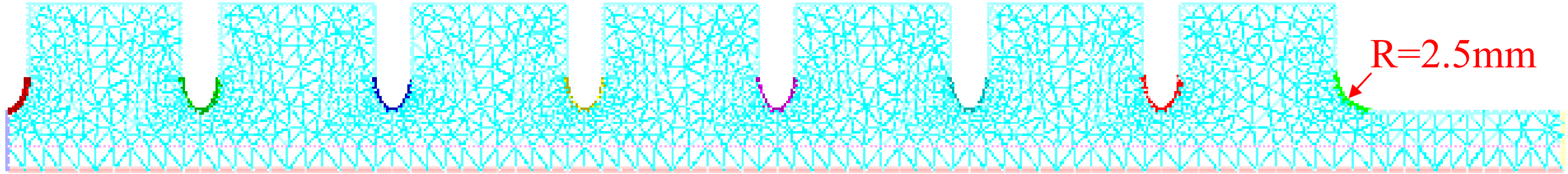
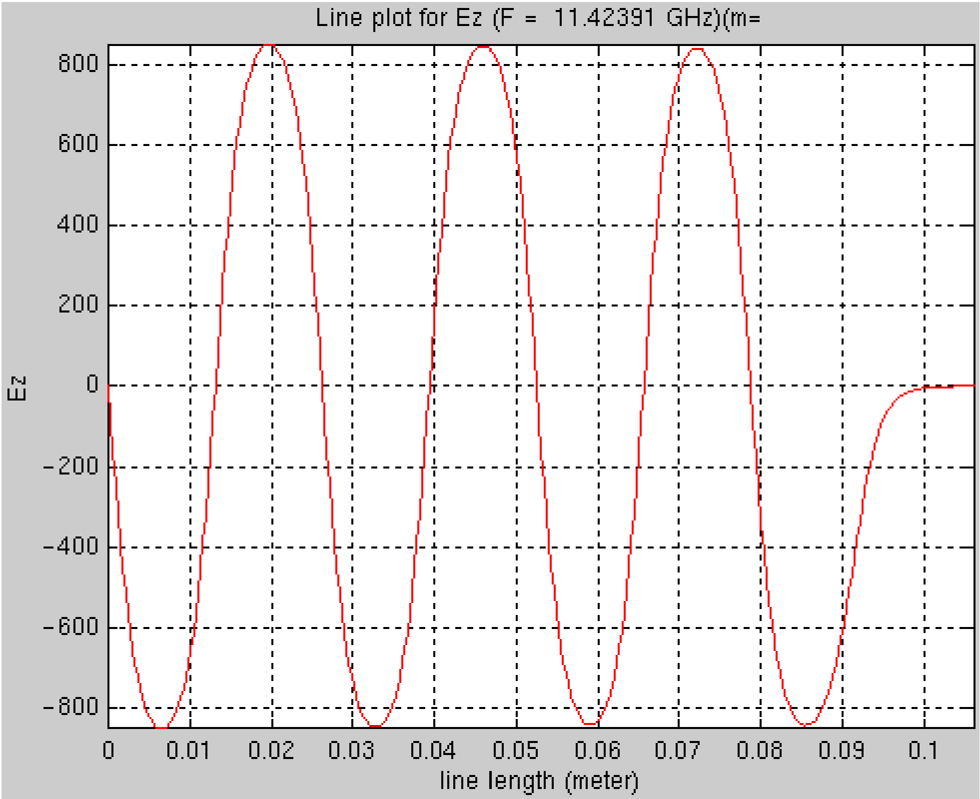
Flattening Field By Adjusting End-plate





KEK SW20A375 Stack

Parameters	SW20A375
a (mm)	3.75000
b (mm) (with square corners)	10.55666
t (mm)	2.6000
a_{nose} (mm)	2.2000
L (mm)	13.12117
R (MΩ/m)	81.92
Q	8621
Es/Ea	2.046
"b" with two r0.51mm fillets	10.56721
ZERO mode frequency	11.2247

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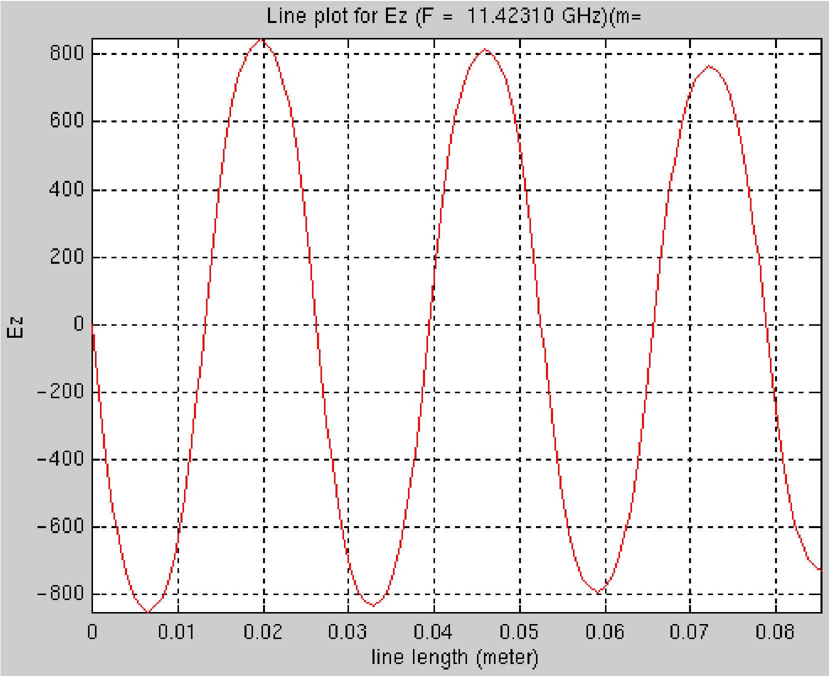
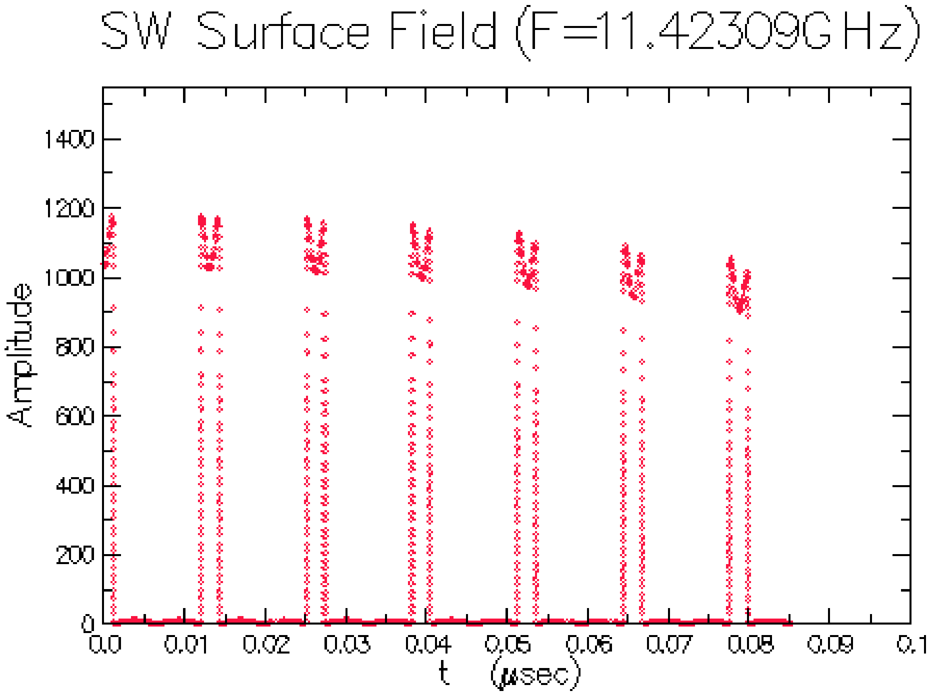
Optimizing Field Profile

- Half of 15-cell stack
- Boundary:M-E
- "b" of coupler cell 10-µm larger





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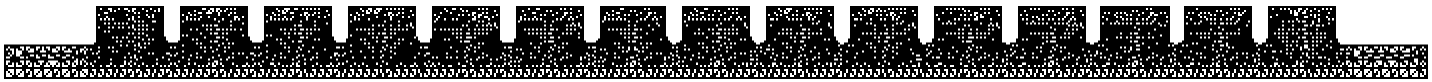
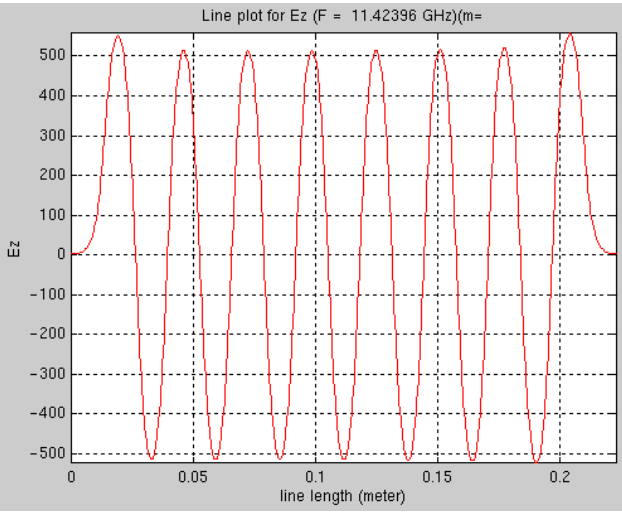
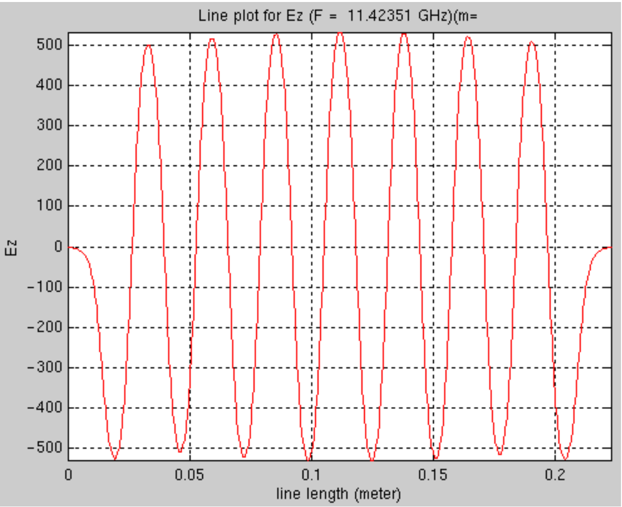
Simulation Of 15-cell Tapered Structure





N	F1 (Hz)	a (mm)	b (mm)	t (mm)
0	1.42E+10	4.85462	10.87390	2.65200
1	1.42E+10	5.14991	10.83400	2.81487
2	1.42E+10	5.13882	11.00350	2.80825
3	1.43E+10	5.12785	10.99830	2.80174
4	1.43E+10	5.11700	10.99330	2.79534
5	1.43E+10	5.10627	10.98830	2.78904
6	1.43E+10	5.09565	10.98340	2.78285
7	1.43E+10	5.08502	10.97850	2.77669
8	1.43E+10	5.07450	10.97370	2.77063
9	1.43E+10	5.06411	10.96890	2.76468
10	1.43E+10	5.05384	10.96420	2.75883
11	1.43E+10	5.04355	10.95950	2.75300
12	1.43E+10	5.03324	10.95490	2.74720
13	1.43E+10	5.02320	10.95030	2.74157
14	1.43E+10	5.01300	10.94570	2.73589
15	1.43E+10	4.85462	10.80320	2.65200



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4	1.43E+10	5.11700	10.99330	2.79534
5	1.43E+10	5.10627	10.98830	2.78904
6	1.43E+10	5.09565	10.98340	2.78285
7	1.43E+10	5.08502	10.97850	2.77669
8	1.43E+10	5.07450	10.97370	2.77063
9	1.43E+10	5.06411	10.96890	2.76468
10	1.43E+10	5.05384	10.96420	2.75883
11	1.43E+10	5.04355	10.95950	2.75300
12	1.43E+10	5.03324	10.95490	2.74720
13	1.43E+10	5.02320	10.95030	2.74157
14	1.43E+10	5.01300	10.94570	2.73589
15	1.43E+10	4.85462	10.80620	2.65200

Test SW (#1 of 4)
cell 1-15
R= 63 MΩ/m

Flat field can be obtained in tapered structure

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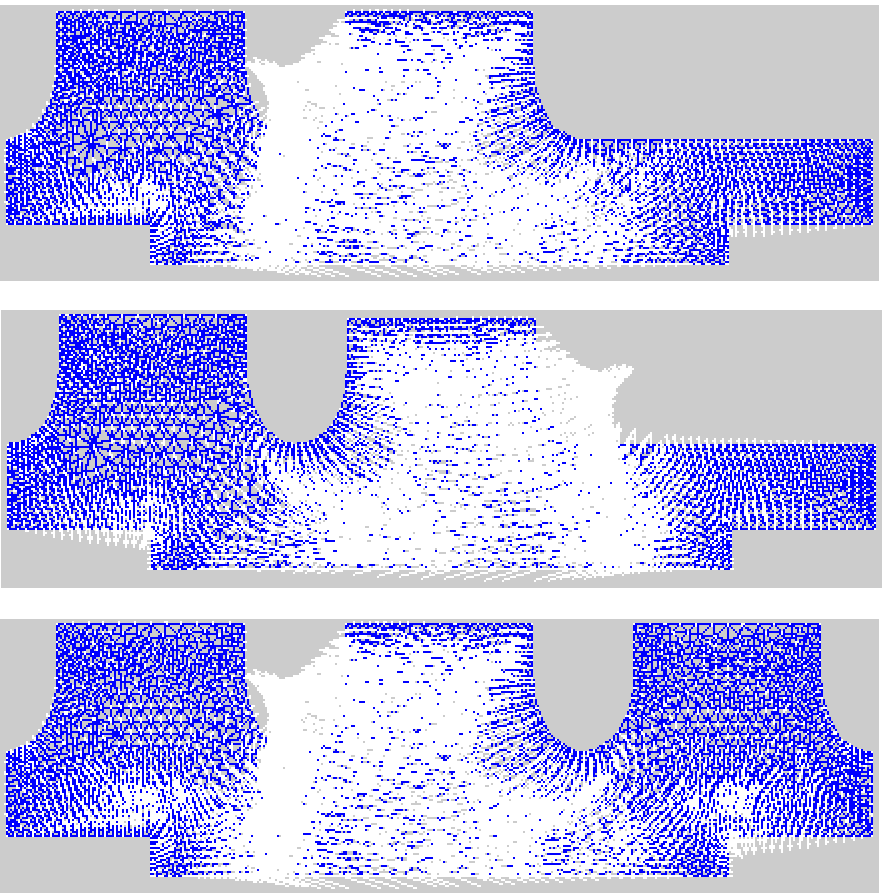
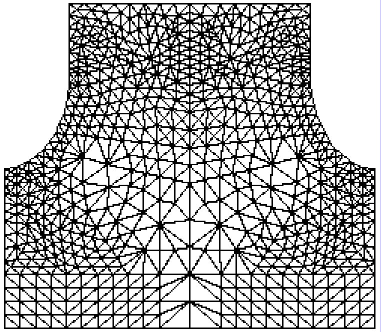
Plunger Measurement Simulation





F_90=11.1279 MHz

Geometric parameters :
a = 5.650000 mm
b = 11.519400 mm
L = 13.121169 mm
t = 4.600000 mm
anose = 3.400000 mm

	Un-tuned	tuned	3 cell
$B_{regular}$(mm)	11.5194	11.5194	11.5194
B_{end}(mm)	11.5194	11.3774	11.5194
F (MHz)	11.1228	11.2727	11.1311

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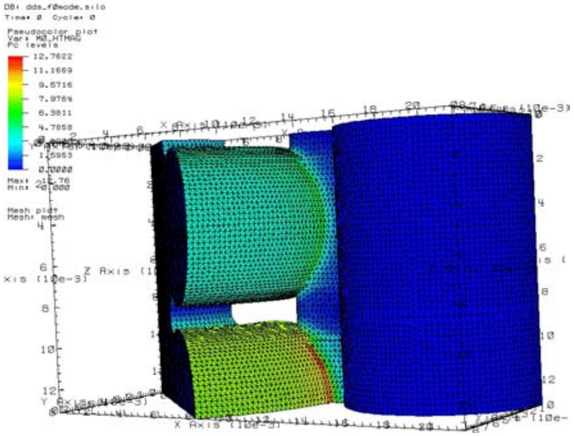
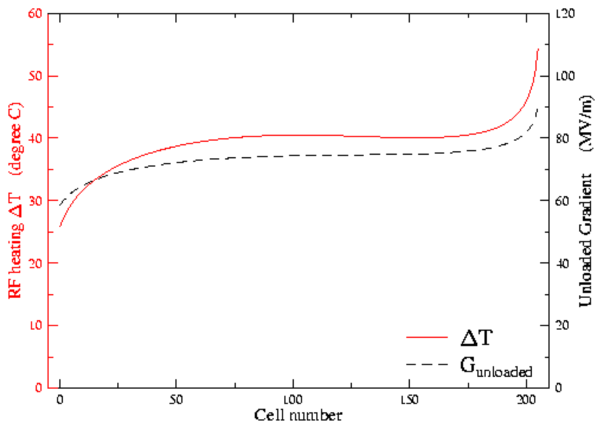
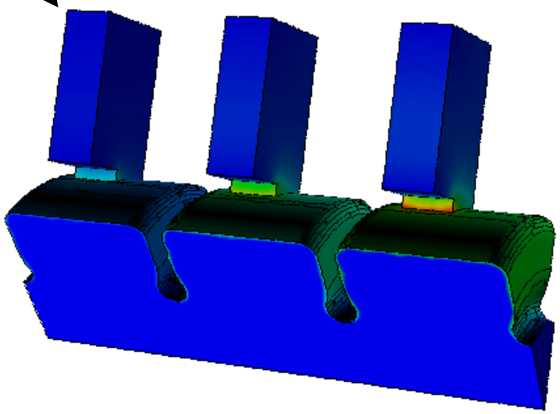
Pulse Heating (G=70MV/m)

RDDS MDDS







- Slots perturb current of accelerating mode. Current concentration at slots produce RF heating
- ΔT: RDDS1: 25^{0}C - 55^{0}C; RDS : <14^{0}C

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